Strategic Munitions Planning in Non-Conventional Asymmetric Operations

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ABSTRACT

Most NATO nations are facing reduced defence budgets, while at the same time participating in multiple demanding operations around the world. Combined with the global economic situation, munitions procurement is under close scrutiny from finance ministers. This paper discusses approaches to strategic munitions procurement in the face of uncertain current and future operations, extended operation duration, procurement/manufacture lead times of months or even years, collateral damage considerations, use of strategic weapons in non-strategic engagements and disposal of obsolete munitions stockpiles.

Current and recent operations, while obviously a good source of data if available, may not reflect future operations or doctrine. As such, the usefulness of historical data must be treated with care.

Methodologies considered by this paper include the Target-Oriented Methodology (TOM), Level-of-Effort Methodology (LoE), Monte-Carlo Simulation, Marginal Analysis and military judgement.

While each approach has its advantages and disadvantages, results need to be robust, objective, transparent and repeatable in order to justify the expense of potentially millions of dollars per munition. Furthermore, it was observed that while several types of weapon system might be able to perform a given mission, there is a trade-off between the cost of the munition and the risk of attrition to the platform utilising it.

This paper demonstrates that, while hard data is always desirable, the uncertain nature of the future makes the use of military judgement inescapable. Detailed scenario development is the key to strategic planning, resulting in the requirement for a mix of munitions guided by the types and quantities of tasks that will need to be executed. For air-launched weapons, the requirement for non-precision munitions is virtually nil, while minimising of collateral damage and scenario duration are key drivers.

Furthermore, this paper recommends that nations, where possible, undertake bi-/multi-national munitions procurement contracts, resulting in economies of scale and avoiding the 'minimum order quantity' obstacle that many smaller nations face when procuring expensive long lead-time munitions. This policy would also enhance interoperability between nations.

This paper concludes that a robust numerical model, which is primarily target-oriented in its methodology, is the most suitable approach to quantitative strategic munitions planning. This model must be based on mature, well-developed scenarios for its results to be credible.

1.0 INTRODUCTION

The impetus for the transformation of NATO was a combination of events, beginning with the end of the Cold War, followed by NATO's involvement in former Yugoslavia, the events of September 11 and the

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14. ABSTRACT

Most NATO nations are facing reduced defence budgets, while at the same time participating in multiple demanding operations around the world. Combined with the global economic situation, munitions procurement is under close scrutiny from finance ministers. This paper discusses approaches to strategic munitions procurement in the face of uncertain current and future operations, extended operation duration, procurement/manufacture lead times of months or even years, collateral damage considerations, use of strategic weapons in non-strategic engagements and disposal of obsolete munitions stockpiles. Current and recent operations, while obviously a good source of data if available, may not reflect future operations or doctrine. As such, the usefulness of historical data must be treated with care. Methodologies considered by this paper include the Target-Oriented Methodology (TOM), Level-of-Effort Methodology (LoE), Monte-Carlo Simulation, Marginal Analysis and military judgement. While each approach has its advantages and disadvantages, results need to be robust, objective, transparent and repeatable in order to justify the expense of potentially millions of dollars per munition. Furthermore, it was observed that while several types of weapon system might be able to perform a given mission, there is a trade-off between the cost of the munition and the risk of attrition to the platform utilising it. This paper demonstrates that, while hard data is always desirable, the uncertain nature of the future makes the use of military judgement inescapable. Detailed scenario development is the key to strategic planning, resulting in the requirement for a mix of munitions guided by the types and quantities of tasks that will need to be executed. For air-launched weapons, the requirement for non-precision munitions is virtually nil, while minimising of collateral damage and scenario duration are key drivers. Furthermore, this paper recommends that nations, where possible, undertake bi-/multi-national munitions procurement contracts, resulting in economies of scale and avoiding the minimum order quantity obstacle that many smaller nations face when procuring expensive long lead-time munitions. This policy would also enhance interoperability between nations. This paper concludes that a robust numerical model, which is primarily target-oriented in its methodology, is the most suitable approach to quantitative strategic munitions planning. This model must be based on mature, well-developed scenarios for its results to be credible.

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subsequent operations in Afghanistan [Ref. 1]. NATO changed its view from in-place, defensive operations in Europe, to rapidly deployable, expeditionary operations well beyond Europe's borders. The shift of focus, particularly in the area of defence planning, from static, monolithic, conventional forces to rapidly deployable, multi-functional forces has not been an easy one for many nations' military forces to embrace. Government in general have been reducing defence spending, based upon the logic that, with the big threat no longer present, surely such large forces are no longer needed. Armed services have been forced to become more efficient, more able to cope with a wider range of tasks and more interoperable.

In recent years developments on the global stage have emerged which have added further pressure to the need to transform NATO and national military structures. These developments include a changing NATO role (supporting everything from disaster relief, to peace keeping, to counter-insurgency missions), combat operations in remote locations that are of a longer duration than ever previously considered and, not least, a global financial crisis.

Given this backdrop, nations still need to plan their procurements in order to support both their national requirements and NATO commitments. This paper considers the issue of determining future munitions requirements.

Considering the wide spectrum of munitions, which covers everything from small arms rounds to long-range, precision guided missiles, two factors are paramount are of prime significance from a procurement perspective (as opposed to an operational perspective):

- Cost (up to millions of dollars per munition)
- Lead-time[1] (up to years)

Clearly a nation has a greater incentive to correctly determine their requirements for munitions with high costs and long lead-times. Failure to do so will result in large over-expenditure or critical shortfalls that cannot be rectified in the short term.

The purpose of any strategic munitions planning it to forecast the amount of munitions required to support military forces across a defined spectrum of operations. In other words, estimate how many of any given munition type a nation will require in the future and then to compare it to how many that nation currently possesses (or plans to possess). This will lead to one of three situations:

- The nation has more than required.
  This situation may appear desirable in a military sense, but it is not desirable for the taxpayer. Excess stocks need to be maintained (and potentially disposed of), which is expensive. However excess munitions may be considered as risk mitigation against the possibility of having an estimate that is too low.
- The nation has about the right amount.
  This situation is obviously the most desirable, though this paper will later discuss the concept that there is no 'single correct answer' when calculating munitions requirements.
- The nation doesn't have enough (or any).
  This situation leads to a need to procure more stocks of that munition type or one with a similar capability.

2.0 THE HISTORICAL CONVENTIONAL CONFLICT

Operational Research has its roots firmly in the realm of Defence. The Second World War, followed by the Cold War, provided extremely well-defined scenarios for analysis. The opponent was well-defined,

[1] The time between placing an order for an item and receiving it.

with a clearly structured, sized and located military force. The principles of Lanchester [Ref. 2] could confidently be applied to these scenarios.

When considering strategic munitions planning, the size and composition of a nations planned stockpile has primarily been driven by the size and composition of the opposing force. Furthermore, historical study had shown that the Defeat Criteria[2] for conflicts was in the range of 30-40%. Additional study showed that in real-world conflicts, the distribution of engagements across platforms could be closely approximated by a mulitvariate Polya distribution (a few shoot many, many shoot few) [Ref. 3].

These combined factors led to the pre-eminent methodology for munitions planning being based on the Target-Oriented Methodology (TOM). Such a methodology has been adopted by several nations (including the USA [Ref. 4, 5]) and NATO. Implementations of this methodology varied in complexity from probabilistic calculations [Ref. 6] to complex optimisation formulations and genetic algorithms [Ref. 7]. However, in all of these models, the primary input was the list of targets that needed to be defeated in order to achieve a strategic victory.

3.0 FURTHER CONSIDERATIONS

Considerations that may be factored into a strategic munitions planning model are listed below. The impact of each of these factors will vary by the nature of the munition being considered and the type of scenario itself.

3.1 Existing Stockpiles

A nation's existing munitions stockpile might affect its choices for future procurement. If a currently owned munition is capable of performing a task, but at a slightly lower performance level than a new munition, then the requirement for the new munition may be reduced. However, a certain amount of duplicate munition capability is acceptable to support increased combat flexibility (e.g. delivery via land, air or maritime) over various types of conflict.

3.2 Munition Cost

Most national procurement policies are driven by budget restrictions. The cost of munitions is therefore often a primary factor in munitions planning.

3.3 Platform Survivability

A munition that reduces the risk of attrition to a platform (e.g. a long-range standoff weapon) is more desirable than a munition without this characteristic.

3.4 Minimum Deployable Quantity

This defined as the quantity of munitions that a platform requires to be considered operationally ready. Therefore, this provides a lower-limit on the total munitions requirement.

3.5 Target Interdependence

The location/occurrence of targets may be correlated (e.g. air defence assets located near runways), resulting in the need for a platform to engage both types of target.

[2] The proportion of an opposing force that needs to be defeated in order to achieve victory.

3.6 Target Range

Some targets may be outside the range of some platforms and munitions. Thus a specific subset of platforms and/or munitions would be required to be able to engage them.

3.7 Platform Availability & Time Constraints

If there is a limited number of platforms available and a limited time within which the operational objective must be achieved, then there may be insufficient capacity of the preferred platform to achieve this. As a result, some of the tasks must be shifted to secondary platforms/munitions.

3.8 Inter-Service Conflict

Defence budgets have always been under pressure. If a given target could be engaged by multiple services, then those services have been known to argue over which of them should be assigned those targets, since more targets results in higher requirements and thus a better chance of more budget.

3.9 False Targets

Munitions may be expended when an incorrect identification of a target has been made. This may be caused by deliberate deception on the part of the enemy (e.g. decoys) or difficultly in target identification (e.g. due to weather).

3.10 Enemy Action

There may be losses of munitions due to enemy action against supply lines or depots.

3.11 Losses Onboard Lost Platforms

If a platform is lost to attrition, it is likely that some munitions remained unexpended onboard. These will be lost with the platform.

3.12 Zeroing

A platform may need to expend some rounds to ‘zero-in’ on a target or set of targets.

3.13 Logistics Allowance

Some munitions will always be unavailable due to various logistics considerations, such as being in-transit, wrongly located or otherwise unavailable.

3.14 Technical Failure

Some munitions will be lost due to the fact that they have suffered a technical failure.

3.15 Environmental Factors

Factors such as weather, terrain, temperature, humidity, dust, etc. can influence the number of munitions required.

3.16 Non-Doctrinal Usage

Munitions may be used in ways which they were not designed or planned for. This consideration is discussed more fully below.

3.17 Geographical Location

When an engagement occurs, commanders will use the most suitable munition available to them to defeat the target. The preferred munition may not be present at the engagement (or unavailable for some other reason). In this case an alternative munition will have to be used.

4.0 THE REALITY OF MUNITIONS PLANNING

4.1 No Single Answer

It is tempting to believe that stockpile requirements determination should result in a single answer of the form "you need N munitions of type M". Unfortunately, any estimate of future requirements is not so simple.

For a given munition, any calculated requirement value has a risk value associated with it. For example, it may be that having a stockpile of 900 munitions results in a 90% chance of running out, whereas a stockpile of 1000 munitions only results in a 50% chance of running out. Increased stock levels lead to lower risk of not having sufficient stock, but at a higher cost.

To further complicate matters, running short of one munition type may be offset by excesses in another munition type of similar capabilities. Therefore, any combined stockpile level has an associated level of risk.

Lesson: Any calculated requirement value has an associated risk that it will be insufficient.

4.2 What You Need vs. What You Can Afford

Fahringer and Smith [Ref. 8] reported that (within the US) the proportion of munitions procured was around 60% of the calculated requirement figures. The reason for this was that the treasury assigns proportions of the limited budget to the most critical shortfall areas. Furthermore, Fahringer and Smith note that the majority of the budget is allocated to ensure that munitions manufacturers achieve the minimum quantity to keep the production lines open. This is known as the Minimum Sustaining Rate (MSR).

This observation is supported by Mengel [Ref. 9] who observed that from 1988 to 1992 the budget for ammunition steadily decreased and then from 1992 to 2002 "training shortages were made up by pulling from the cold war stockpiles". This resulted in a dwindling national stockpile and a significantly reduced national production capability. However, Mengel does lay the majority of the blame for the ammunition shortage problems at the feet of logistic accountability, visibility, reporting and distribution (i.e. that enough was present in theatre, but it was not in the right place). These logistics topics do not fall within the scope of this paper.

The conclusion to be drawn here is that, in reality, determining the exact requirement for a given munition is not necessary. What is useful is determining an approximation of the requirement that allows shortfalls in current stocks to be evaluated and budget allocation to be prioritised. Whether there is sufficient budget available to meet the shortfalls is also a matter outside the scope of this paper.

Lesson: Calculated requirement figures may not be procured, but used to prioritise shortfalls.

5.0 RECENT OPERATIONS

The past decades have changed the strategic planning landscape completely. Many of the fundamental assumptions that were previously accepted no longer hold true. From the bombings of Belgrade during the

Kosovo crisis, to the campaigns in Afghanistan and Iraq, the preconceptions of many planners have had to be cast aside and a new way of thinking adopted [Ref. 10]. It is useful to attempt to consider each of these changes in turn:

5.1 An Ill-Defined, Militant, Non-Conventional, Regenerating Opposing Force

With current counter-insurgency operations, the opposing force is not easily quantified. Scattered groups of insurgents, who are largely indistinguishable from the local population, are hard to count in the same way as a convention force is. What is more, by their very nature, insurgent groups are continually recruiting new members, resulting in new opponents emerging just as others have been dispatched.

Lastly, the nature of the conflict does not favour a purely military solution. In what has been termed 'nation building' operations, the approach to counter-insurgency operations is believed to lie in a combination of social, political and military actions [Ref. 11]. The role of the military is to control insurgent activities until the social/political/economic conditions have arisen that make insurgent activities unviable. As such, there is no clearly defined 30-40% defeat criterion applicable. Moreover the fanatical nature of many militants would likely raise this value closer to 100% even if the size of the opposing force could be measured.

Lesson: Target lists alone are now insufficient to determine munitions requirements.

Lesson: The size of the target list to be defeated is a risk factor itself.

5.2 Non-Doctrinal Usage

Many counter-insurgency engagements are of a small scale. MkNaught [Ref. 12] demonstrates that in an asymmetric campaign, it is clearly in the interests of the smaller side to engineer a series of smaller engagements rather than a few large engagements. This prevents their opponent from taking advantage of their greater force strength.

As a result, these engagements see a large expenditure of small arms and small-medium calibre mortars. What was not foreseen until recently was the increase in the number of small sized air-launched precision weapons, medium calibre cannon rounds and man-portable guided weapons. Units engaging small groups of insurgents in difficult locations (mountainous or urban regions) would either request air support (e.g. to engage an enemy entrenched behind a mountain ridge) or engage the enemy with 'overkill' weapons (e.g. using a shoulder-launched anti-armour system to engage a sniper in an urban building). Previous doctrine was to prosecute these engagements with small arms, but the political, financial, ethical and moral cost of using these overkill weapons is less than losing the lives of either troops or civilians.

When employing weapons against non-doctrinal targets, these targets are also sometimes referred to as non-conventional targets.

Lesson: Engagements may not follow pre-conceived doctrine.

5.3 Harsh Environments

Operations that are occurring in environments that are very hot, very cold or very dusty, etc. can have a significant effect on munitions requirements. If an air-launched munition can only be flown a few times before it must be discarded (known as the 'air carriage life' of a munition), then the requirements for that munition will probably be driven simply by the number of sorties required to be flown (operation duration x number of sorties per day) and not by the number of targets at all.

5.4 Improved Munitions Performance

Since the end of the Cold War, the direction of munitions development has changed. Range and accuracy are of primary importance, as well as lethality. The political and moral need to reduce collateral damage, combined with the operational need to employ weapons in or around urban environments have led to the development of munitions with significantly improved accuracy, range and lethality.

Freeman [Ref. 13] notes that these improvements in the performance of munitions will reduce the overall requirement. Less obviously though, he notes that this will reduce the strategic lift and logistics footprint required for an operation, making forces more responsive and deployable.

6.0 AVAILABLE METHODOLOGIES

Several methodologies are available to the analyst for determining munitions requirements. Each has strengths and weaknesses. Given the importance of ensuring that sufficient munitions are available to support current and future operations, together with the large sums of money involved, any selected analysis needs to be objective, robust, transparent and repeatable.

A methodology that relies on the judgement of an individual or group of individuals is unlikely to achieve agreement, especially in an environment where multiple groups are competing for the same budget.

The main methodologies considered for munitions planning are broken down in the figure below. Note that in the Target Oriented case, platform-target proportions (e.g. 60% of the enemy tanks will be destroyed by our tanks) may or may not be predetermined.

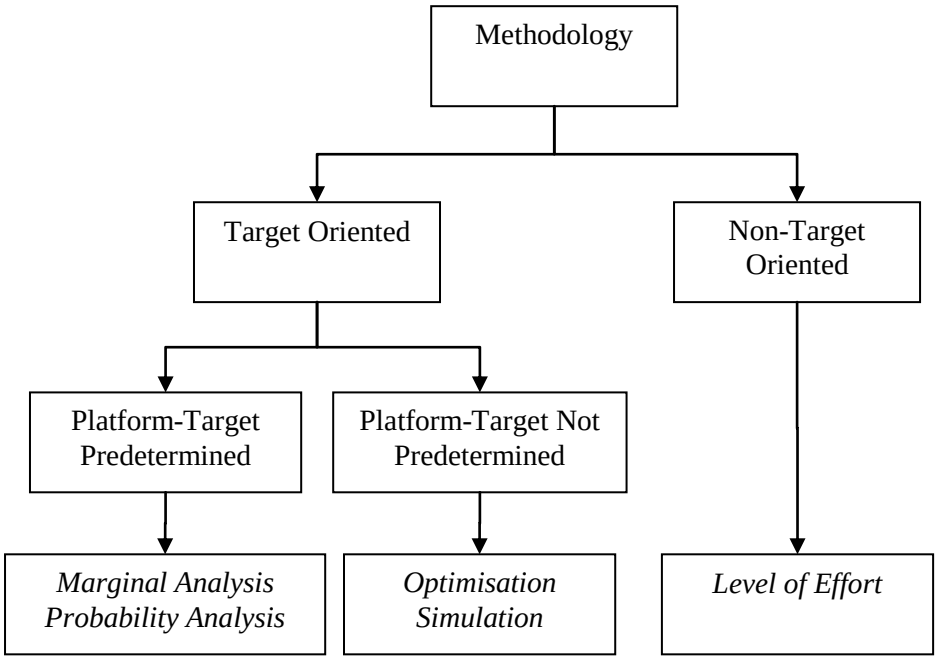

Figure 1: Munitions Planning Methodologies

Note that Figure 1 does not purport to be an exclusive list of available methodologies, but merely lists the most commonly used ones in this area. This paper will not discuss in detail each of the possible implementations of a target-oriented methodology, but will discuss the overarching principles of the approach.

Note that a hybrid methodology is an option. This possibility is explored more fully later on in this paper.

6.2 Target Oriented Methodology (TOM)

The Target Oriented Methodology (TOM) is the most widely used approach to munitions planning. Essentially it poses the question "How many munitions would be required to defeat a given set of targets?" There are various methods of tackling this question, but all of them require a clearly defined set of targets from which to derive munitions requirements values.

An important aspect of the TOM is that it is time-independent, unless platform availability is being considered (see section 3.7). It will take the same quantity of munitions to defeat a given target list regardless of whether this is done in one week or one year.

In general, this independence from time is an advantage of the TOM. However, there are situations where it causes problems. For example, consider regenerating targets, such as airbase runways (which can be repaired after a short time) or insurgent troops (which are being recruited or transported into theatre at a relatively constant rate). For these target types, the number of targets to be defeated is a function of time and thus the size of the target list is dependent upon the expected duration of the scenario.

6.3 Non-Target Oriented Methodology

The Level-of-Effort (LoE) methodology is the only widely accepted methodology that does not rely on a pre-defined target list. The LoE methodology has been applied to planning for centuries. Its strength lies in its simplicity and ability to use historical data. Fundamentally, it assumes a constant rate of consumption and multiplies this by the duration required.

$$Req = Rate \times Duration$$

The consumption rate is usually defined as a base rate which is modified by a set of operational and environmental factors, sometimes referred to as Combat Planning Factors (CPFs), which result in a consumption rate applicable to a specific scenario.

The US Marine Corps [Ref. 14] identified that many existing methodologies used significantly overestimated the munitions requirements and recommended that planning be based on consumption data gathered from recent operations only. It also notes that "the […] model calculates CPFs only for major combat operations against a composite (armor-infantry mix) threat force. These CPFs fail to capture the unique weapon mix and utilization required to combat insurgent forces or perform military operations on urban terrain".

Clearly, accurate determination of the rate is vital to the validity of this approach. There are various ways of determining a consumption rate with confidence.

6.3.1 Historical Data

Data gathered from actual past campaigns is applicable as long as the campaign is homogenous to the one being modelled.

6.3.2 Combat Day of Supply (CDOS)

Many nations define their consumption rates in a scenario as a Combat Day of Supply (CDOS). This is obtained from defining a Standard Day of Supply (SDOS) and modifying it by a set of operational and environmental factors specific to the scenario. This approach assumes that the modification factors are constant and independent (i.e. are not correlated) and that the SDOS (which is usually derived from historical data) is valid.

6.3.3 Simulated Data

If no suitable historical data is available and insufficient data is available to confidently derive CDOS, then the rate may be estimated by modelling the scenario. Essentially this means that a TOM is used to estimate an average consumption rate.

The advantage of this approach is that once a set of complex and detailed modelling activities have taken place, the derived numbers may then be used for the simple LoE calculation *for homogenous scenarios*.

7.0 STRATEGIC MUNITIONS PLANNING IN THE CONTEXT OF TRANSFORMATION

7.1 Targets vs Capability

The need to perform a wider range of functions in a wider range of operations has proven paramount in recent years. However, it remains true that munitions are essentially good at one thing only; namely destroying targets. Even in the role of 'force presence', where no munitions are actually expended (if all goes well), it is the *potential* of the munitions stockpile to destroy targets that creates the necessary deterrent[3].
One of the primary drives of transformation in NATO is to perform planning based on capability as opposed to force strength. Most capability-based planning, as it is currently performed, involves breaking down missions into a collection of 'mission tasks'. In order to produce quantitative munitions requirements in a capability-based context, a number of mission tasks for munition expenditure would have to be generated. These might be of the form 'destroy a runway'. Thus, in general for strategic munitions planning, capability-based planning is target-oriented planning by another name.

7.2 Don't Plan To Fight the Same War Again

The concept of Transformation is based on the understanding that the world is a rapidly changing place [Ref. 1] and the experiences of one operation may not be applicable in another.

Based on this tenet, it is vital to define in detail a range of future scenarios (some of which may be occurring simultaneously) upon which to base munitions planning. Without such scenarios, it is impossible to demonstrate a robust munitions requirements analysis that was not based solely on historical data.

The set of scenarios should test the range of scenarios (and possibly concurrent scenarios as well), that are envisioned as being potential future operations. Rather than viewing the scenarios as driving the requirements, they may be viewed as testing the robustness of the stockpile capability against a range of conflicts, thereby identifying capability shortfalls.

Lesson: Detailed scenario definitions are vital.

7.3 Long Term Operations

Almost all of NATO's operations within the past two decades have durations that are measured in years. The nature of these long-term operations, which may be considered as effectively indefinite for strategic planning purposes, creates a difficult problem with regard to munitions planning, where many items have lead times that are measured in months or years.

[3] It is important to note that if a munition is used in a primarily deterrence role, then training expenditures may significantly exceed operational expenditures.

In an indefinite scenario, the LoE equation defined in section 6.2 is impossible to solve, as we do not have a value for 'duration'. In this case we may apply some rules, such as:

- Have at least 6 months (180 days) stockpile
- Have sufficient stockpile to allow for resupply
  - Must be at least the manufacturing lead time
  - Must allow for lag between start of operation and placing of a resupply order

Thus the LoE equation may be modified to become:

$$Req = Rate \times max(180, min(Duration, LeadTime + Lag))$$

For example, if for a given scenario (with indefinite duration) and munition with a lead time of 360 days and a lag of 60 days, the LoE requirement would be for (Rate x 420) munitions.

Lesson: Munition lead time has a large impact on munition requirements.

7.4 The Role of Military Judgement

Strategic planning is, by definition, making an educated guess about an uncertain future. As such, there are unknowable and unmeasurable factors that will have a significant impact on the munitions requirements. In these situations, military judgement is necessary.

The judgement of one military expert may be significantly different from another. This presents problems in terms of objectivity and repeatability. These issues can be mitigated by the following actions:

- Obtain a consensus judgement from multiple expert sources.
- Document the rationale behind each judgement, rather than simply the value itself.
- Where applicable, validate the judgement using historical data.

By obtaining judgement values from multiple sources, a distribution of values may be determined for these uncertainties.

Lesson: Military judgement is necessary, but obtain it from multiple sources.

7.5 Specialisation & Standardisation

As noted above, if the majority of the available national defence budget is allocated to sustain the industrial production base, a significantly reduced budget is not able to address actual shortfalls between current stockpiles and munition requirements. This situation can be alleviated by spreading the MSR quantities between nations via multi-national agreements.

Furthermore, smaller nations wishing to purchase munitions may find that they cannot meet the minimum order quantity required by the manufacturer, or will not obtain a good deal due to economies of scale.

Multi-national agreements to coordinate procurement of munitions would ensure that all nations are getting the best possible deal due to increased economies of scale. Furthermore, if smaller nations committed to a small annual procurement, it would reduce the allocation of budget from larger nations to ensure MSR. This would free up more budget to address other shortfall areas.

Lesson: Multi-national agreements for munitions procurement will reduce pressure on national defence budgets.

8.0 A PROPOSED METHODOLOGY

Based upon this array of uncertainties and unknowable quantities, it may seem that estimating munitions requirements is not possible. However, this paper presents a coherent and transparent framework for estimating the requirement figures for any given munition.

For every munition *m*, we shall break down the required quantity, within some scenario *s*, into three component parts. These will be:

- $ExpTgt_{m,s}$: Munitions expended against strategic targets
- $ExpNonTgt_{m,s}$: Munitions expended but not against strategic targets
- $NonExp_{m,s}$: Munitions not expended (e.g. logistics allowance, technical failure, etc)

The analyst must select an appropriate methodology for each component. The first item ($ExpTgt_{m,s}$) lends itself to a TOM, but this is not compulsory. For example, all three components may be modelled by LoE. Similarly the third component ($NonExp_{m,s}$) does not lend itself to TOM, but may be modelled as a percentage 'overhead' to the other two components. Once again, this remains at the discretion of the analyst.

Furthermore, as noted above, the basic load requirements of platforms provide a lower bound for munitions requirements.

If the value for $NonExp_{m,s}$ is taken as a percentage overhead as suggested, then the requirement may be formulated as follows:

Let *s* be a scenario in the set of scenarios S (for simplicity here, we shall not consider sets of concurrent scenarios).

$$Req_{m,s} = \max\left(BasicLoad_m, \left(ExpTgt_{m,s} + ExpNonTgt_{m,s}\right).\left(1 + NonExp_{m,s}\right)\right)$$

$$Req_m = \max_{s \in S}\left(Req_{m,s}\right)$$

It should be noted that this approach may not provide the optimum mix of munitions across the range of scenarios. Nor does it explicitly make any consideration of existing stockpiles or the munition cost. Based on the context discussed above, that any transformation of national forces must include a transformation of national stockpiles and also an understanding that the requirement figures calculated will only be used to inform the allocation of a limited budget, these limitations may be accepted.

However, we have also determined that the requirement figure is, in fact, associated with a risk that it is insufficient. Therefore, we are performing a trade-off between risk and stockpile level.

In order to quantify this scale, we propose to perform three separate calculations for each munition type:

- Optimistic (Req_m^0)
- Expected (Req_m^*)
- Pessimistic (Req_m^1)

where .

In this case the three requirement figures are calculated using optimistic, expected and pessimistic values for the input data. This will provide the strategic planner with some understanding of the level of risk associated with each stockpile.

9.0 DISCUSSED EXAMPLES USING SPECIFIC MUNITIONS

Presented here are two discussions of specific munitions using the proposed framework. The target-oriented methodology is selected for demonstration purposes only. All data is fictitious.

9.1 Application to Patriot-3 Missiles

Patriot-3 missiles are designed to be used against Tactical Ballistic Missiles (TBMs). They are very expensive, have a very long lead time, are highly effective and are highly specialised. Due to the cost and importance of these systems, they are controlled and maintained very carefully, resulting in low logistics allowance and technical failure rates.

It is assumed that no other service or platform may engage these TBM targets, meaning that the targets do not have to be split in any way.

Given the nature of the system, the following observations may be made:

- Few missiles will be lost to non-expenditure issues, due to the fact that they are highly maintained and monitored. Also, their range and specialisation will make them unlikely to be lost to enemy action or unavailable to due to geographical location.
- Few (if any) missiles will be used to engage non-doctrinal targets, due to the specialised nature of the system and the high target acquisition and identification capability.
- The enemy will have a limited number of targets which do not regenerate. In many scenarios, the enemy will not have any TBM targets against which this system would be used.

Therefore, we can surmise that in our munitions requirements calculation, independent of which methodologies we select, the majority of the requirement will be driven by the target list.

9.2 Application to NLAW (Next Generation Light Anti-Armour Weapon) Missiles

The NLAW is a disposable, man-portable, short range fire-and-forget anti-tank guided missile system. As such it is a completely different munition to the Patriot-3. It is relatively cheap and has often been used against ‘soft’ targets in recent operations. It is designed for use against armoured targets (MBTs, AFVs, APCs, etc). It may be fired from an enclosed space, such as from a window in a small room.

As such, it ‘competes’ with many other systems for targets (e.g. tanks, strike aircraft, etc). For the purpose of this example, we shall assume that military judgement has been used to estimate the proportion of each target type that will be engaged by NLAW in each scenario.

Lastly, since the NLAW is a disposable system, there is no distinction between the platform and the missile. However, it is probably known how many troops will be equipped with the system and this may be used at the number of ‘platforms’.

Given the nature of the system, the following observations may be made:

- The usage of this system will different significantly between conventional and non-conventional operations.

- In a non-conventional operation, there may be a high usage of this system against non-doctrinal, regenerating targets. Furthermore, in these operations, the enemy will have few armoured targets of the type this system was designed to be used against.
- The system is robust against harsh environmental conditions.
- While it is likely that this system will be relatively ubiquitous in theatre, there is a possibility that units may expend all of their munitions and fail to be resupplied in time.

Therefore, we may conclude that in a non-conventional operation the munitions requirements will primarily be driven by non-doctrinal engagements (which may be modelled by either TOM or LoE methodologies) and logistics allowance factors.

10.0 CONCLUSIONS

This paper attempts to identify the factors which affect the requirement value for strategic munitions planning. It is observed that munitions essentially only have one capability, namely destroying targets. As such, any approach to munitions requirement needs to quantify the number of targets that need to be destroyed. This in turn leads to the observation that detailed scenario development is central to determining munition requirements and identifying capability shortfalls.

It is also observed that, given the number of unknowable and immeasurable factors, military judgement (supported where possible by historical analysis) is an essential part of the scenario development. As such, munitions requirements figures should not be presented as a single value, but as a range of values with associated risk. This range of values may be large.

It was proposed that munitions requirements may be broken down into three components; expenditure against doctrinal targets, expenditure against non-doctrinal targets and non-expenditure. It was also proposed that each of these components should be calculated using the most appropriate methodology, resulting in an overall hybrid methodology. It was shown that the impact of each of these components varied significantly by both weapon type and scenario.

It was observed that the constraint of national defence budgets and industrial production minimum levels may play a more significant role in actual procurement levels than the requirement figures themselves. The role of the munitions requirement figures may then be considered as informing and prioritising the allocation of available national defence budgets.

Lastly, it was suggested that an increased effort towards multi-national agreements would reduce the impact of industrial MSRs on national defence budget allocation, releasing more funds to address actual shortfalls between actual stockpiles and calculated munitions requirements.

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